Space Weather Technical Forecast

Issued on Sunday, 06 August 2023 at 13:33 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1-G2 Minor/Moderate storm Likely at times from CME arrivals Days 2-3. Further R1-R2 Radio blackouts likely Day 1, then chance of isolated R1-R2 Radio Blackouts Days 2-3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High an X-flare in the last 24 hours. Peak flare of X1.6 at 05/2221 UTC from AR3386 near the western limb. This is a compact region, primarily composed of two moderately sized spots, but with surrounding small spots leading to increased complexity. Otherwise, occasional C-class flares have been observed from a number of regions on the disc. Of the seven numbered (and two unnumbered) regions on the visible disc, AR3387 in the northwest is the only other notable region at present, previously exhibiting a small mixed polarity delta spot to its southeast. The other regions currently on the disc have so far been relatively stable, and either mature unipolar regions, or smaller bipolar regions. The X1.6 flare produced a significant CME with preliminary values entered into Enlil for modelling. Several smaller CMEs have been observed on imagery in the past 24hours, but these are not considered significant nor directed towards the interior planets.

Solar Wind / Geomagnetic Activity: Solar wind speeds as recorded by ACE at L1 have been predominantly at slow-ambient levels and are currently fluctuating around 350 km/s. Density was initially above average, with a peak of 15 ppcc, but has since fallen to below average levels. The total interplanetary magnetic field strength (Bt) has been Weak to Moderate 6-8nT. The north-south component, (Bz) has mostly been weak and towards the north (positive) with a brief southward period 05/1730-1830 UTC. Phi angle has been largely positive (away from the Sun). Geomagnetic activity was initially Unsettled (Kp3) due to the waning influence of a CME arrival on 05 Aug, but has since been Quiet (Kp0-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was initially at S1 Minor Radiation Storm levels peaking at 05/1645 UTC, where it largely remained until 06/0530 UTC at which point it fell below the S1 threshold. Proton flux levels continue on a downwards trajectory. GOES16 high energy (greater than 2MeV) electron flux was at background levels throughout. The associated 24-hour integrated fluence remained well below the Active level (1e8 integrated pfu), with 1.20e6 integrated pfu recorded at 06/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-flares are likely initially, mainly from AR3386 or AR3387, with a decreasing chance of M-flares from Day 2 (07 Aug) onwards as these regions rotate across the western limb. Overall activity this period High initially but expected to reduce, becoming Moderate to Low by Day 2.

Solar Wind / Geomagnetic Activity: Activity is expected to be initially Quiet to Unsettled (Kp 0-3). Increasing to Unsettled or Active (Kp3-4) Days 2-3, with G1/Minor Geomagnetic Storms likely. Chance of G2/Moderate Storm intervals, most likely later Day 2 or early Day 3 (08 Aug). Activity then declining Day 4 (09 Aug) in the absence of further CME arrivals. Solar winds expected to remain largely at or close to background levels Day 1, increasing 450-500 km/s,

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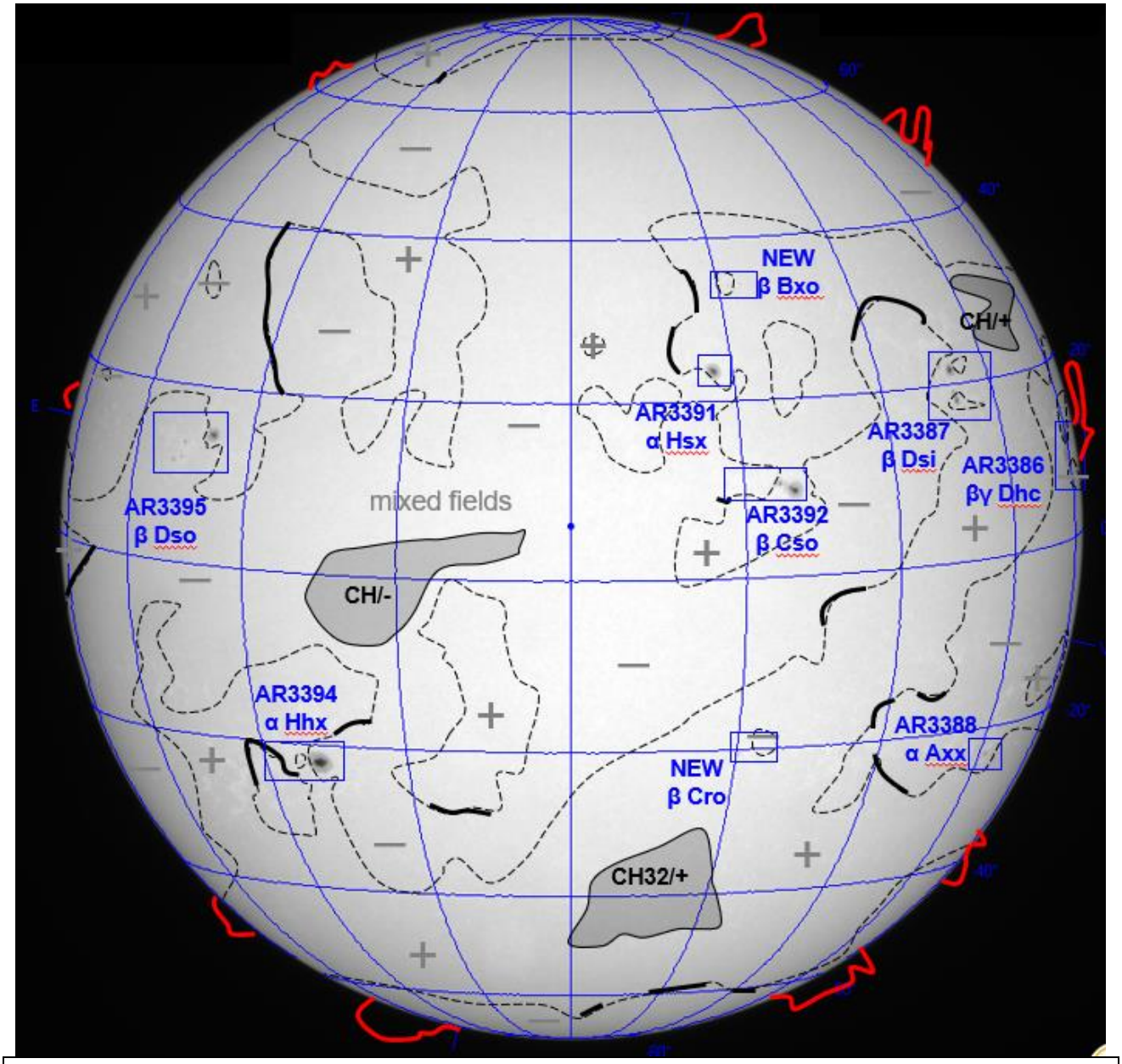
possibly 600km/s in response to CME arrivals Days 2-3.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is currently below the S1 Minor Storm Level. Chance of further enhancement back above the S1 Minor Storm Level Day 1 (06 Aug), but this is a diminishing risk. The high energy electron flux (greater than 10 MeV) has the potential to briefly become enhanced later Day 1 or Day 2 (06-07 Aug) as current CME influence recedes, however this will be suppressed by further CME arrivals in the period. The associated fluence likely remaining below the Active threshold (1e8 total pfu), but with a slight chance of rising above, mainly early Day 2.

Figure 1. Solar Analysis Valid 06/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CME arrival on 05 Aug has been attributed to an early arrival of the CME which left the Sun around 02/0900 UTC following a filament eruption near centre-disc. Ongoing enhancement from this CME continues to wane through Day 1 (06 Aug) with Quiet to Unsettled (Kp0-3) conditions expected to prevail and solar winds likely to remain at (or close to) slow-ambient levels.

A number of CME arrivals are then anticipated through the period. A complex eruption from the northwest disc involving a flare and a filament lift off 05/0430-0600 UTC is considered to have produced two separate CMEs which are predicted to arrive at Earth during the UTC afternoon of Day 2 (07 Aug) Analysis of a further CME observed associated with the long period M1.6 flare from AR3386 at 05/0719 UTC suggests an almost concurrent glancing arrival. There is some potential for these to combine into a single more notable arrival later Day 2. The X1.6 flare, also from AR3386, at 05/2221 UTC produced a significant CME with Enlil modelling supporting a glancing blow at Earth early on Day 3 (08 Aug). Analysis of this feature is relatively low confidence, with updates to the forecast likely in future issues.

Geomagnetic activity is likely to be initially Quiet (Kp0-2) with a chance of isolated Unsettled intervals on Day 1. Activity is expected to increase to Unsettled to Active (Kp3-4) Days 2-3 with G1/Minor Geomagnetic Storm intervals likely. There is also a chance of G2/Moderate Storms, most likely late Day 2 or early Day 3. Activity then declining into Day 4 (09 Aug) in the absence of further CME arrivals.

Solar wind strengths are expected to remain at or close to background levels on Day 1, seeing enhancement upon CME arrivals to 450-500km/s, possibly becoming Strong (600 km/s) for a time late Day 2 into Day 3. Coronal hole (CH32/+) in the southwest of the disc may produce some slight enhancement to the solar winds Days 2-4, however, this is likely to be obscured by the forecast CME arrivals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	10	60	70	30
Strong	G3	No	1	10	15	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/0800	Partial	Flare	AR3386	920 km/s	07/1200-2400 UTC	Glancing Blow
04/1023	Partial	Filament	NE	595 km/s	07/1200-2400 UTC	Glancing Blow
05/1030	Partial	Flare/Filament	AR3386	1020 km/s	07/1200-2400 UTC	May combine to give more significant arrival.

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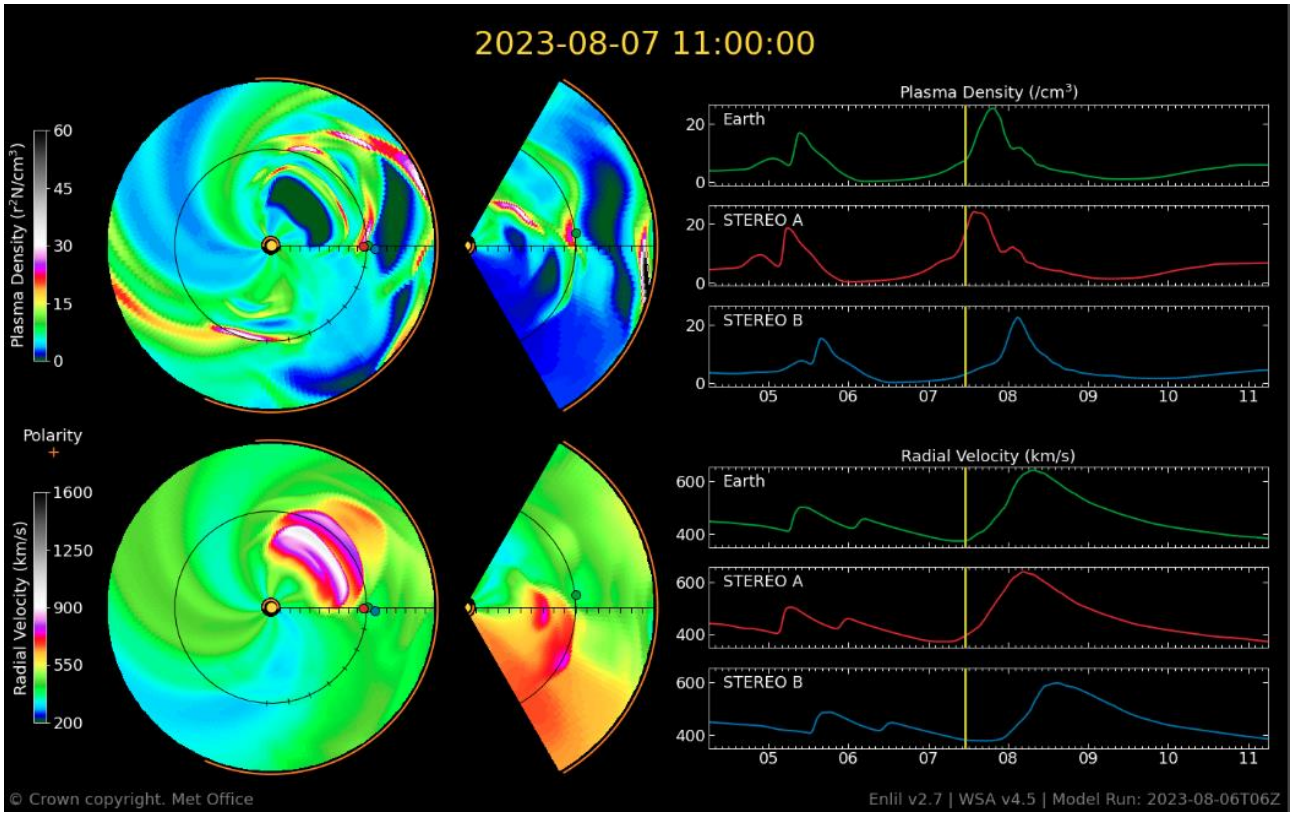
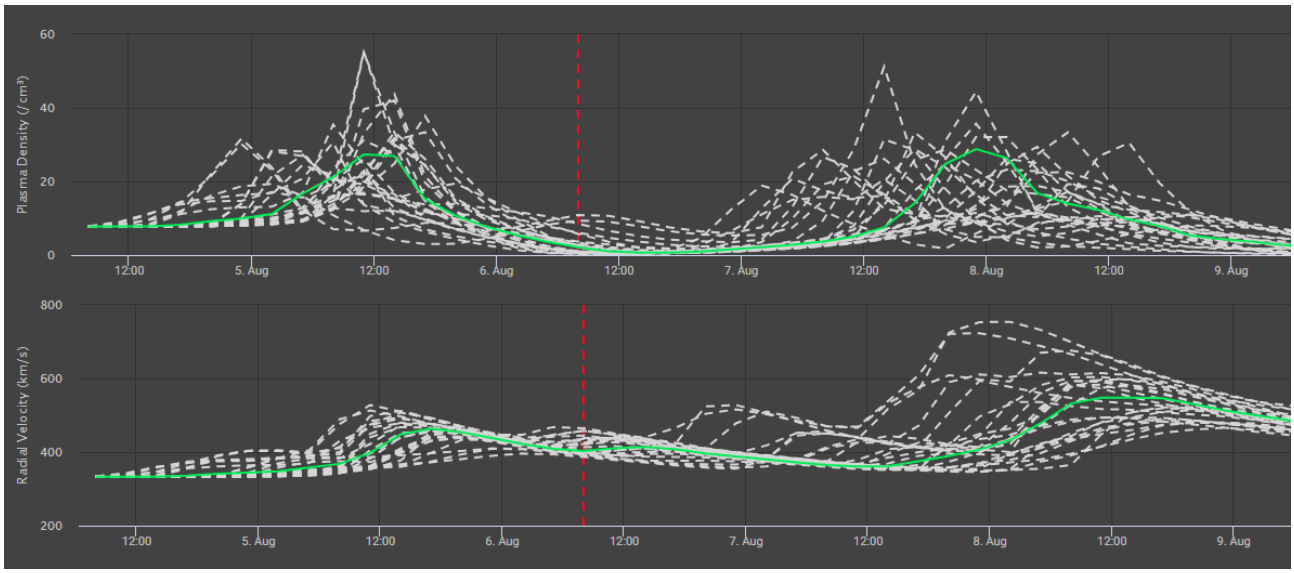
06/0133 UTC	Partial	Flare	AR3386	1120 km/s	08/0200 +/- 6 hours	Glancing Blow

Figure 2: MOSWOC Enlil and Ensemble Output showing complicated arrivals





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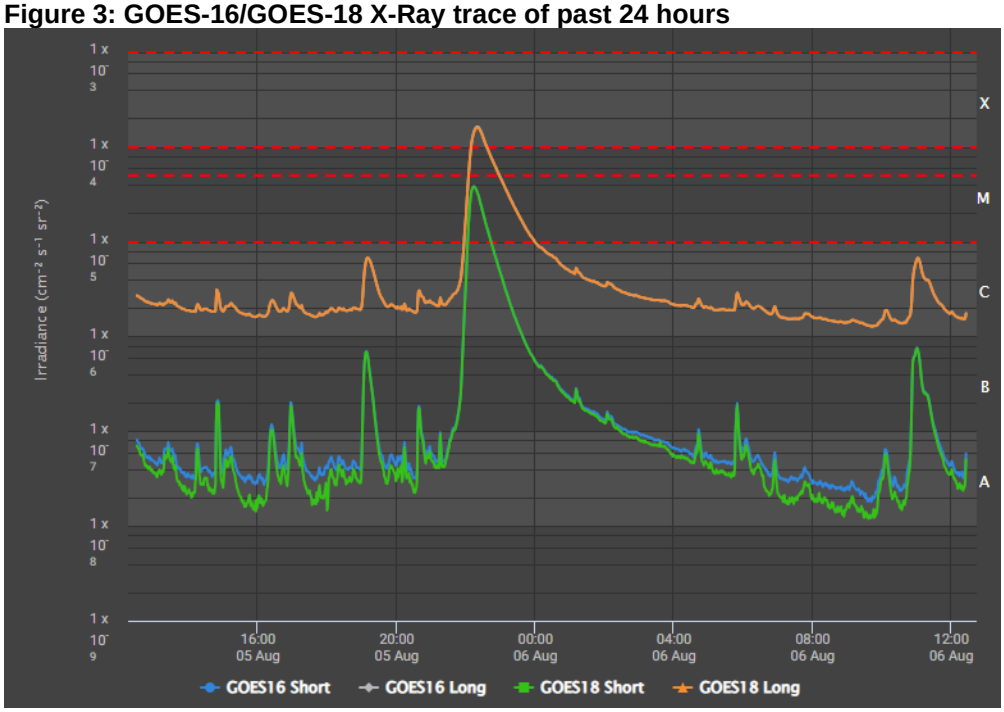
Radio Blackouts - X-Ray Flares:

Activity is currently High following the X1.6 flare at 05/2221 UTC from AR3386 in the west. There are currently seven numbered and two unnumbered regions on the visible disc.
AR3386 (Dhc/Beta-Gamma) towards the western limb remains the largest and the most active region on the visible disc, as well as the most magnetically complex. Analysis of this region is becoming increasingly difficult as it approaches the western limb. AR3387 (Dsi/Beta) in the northwest has simplified magnetically, with its delta spot having recently split and weakened. However, limited SDO imagery at the time of earlier analysis limits confidence in this decline. AR3395 in the east has shown some development in its trailing portion and was reclassified as Dso/Beta, and may become more complex as it rotates across the disc. All other regions remain relatively simple or stable, and have shown limited growth.

Further M-flares are likely initially, mainly from AR3386 or AR3387, with a decreasing chance of M-flares through the period. Activity is expected to reduce to become Moderate to Low by Day 2 (07 Aug). There are a number of bright areas visible on STEREO-EUVI imagery that suggests new regions may rotate onto the disc by Day 4 (09 Aug), with an uncertain contribution to flare probabilities at the end of the forecast period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	50	40	20
Very Active	R3 to R5 X Class	Yes	10	5	5	5

Figure 3: GOES-16/GOES-18 X-Ray trace of past 24 hours



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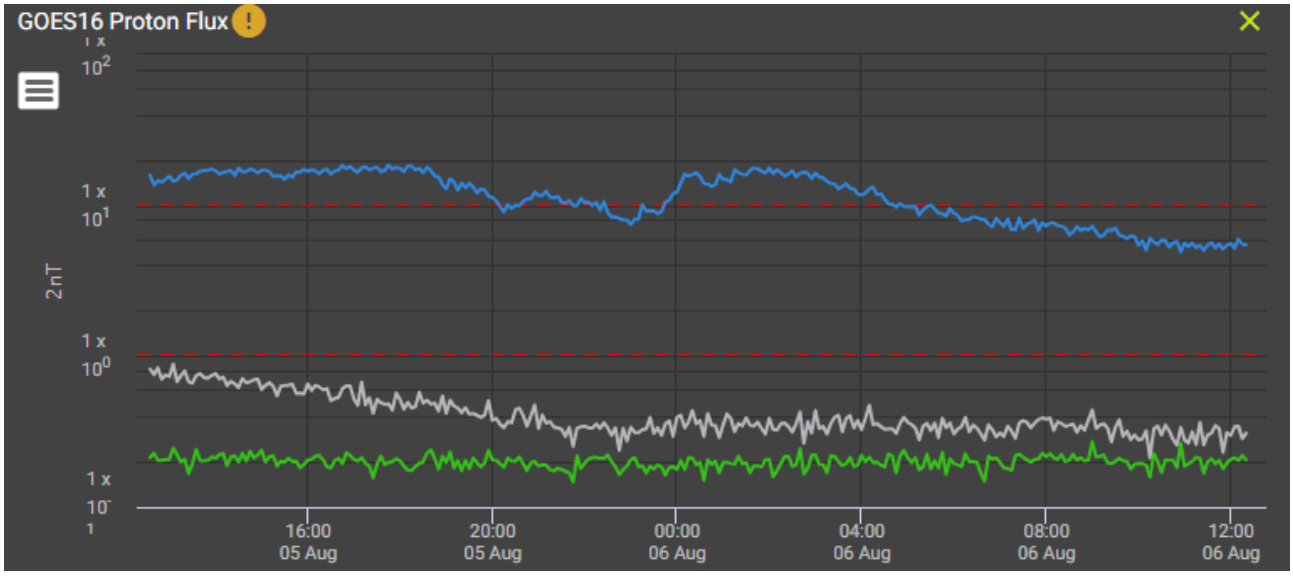
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10 MeV) proton flux dropped below the S1 Minor Storm Level around 06/0530 UTC as enhancement from recent significant flare activity wanes. Further enhancement back above the S1 Minor Storm Level may occur on Day 1 (06 Aug). However, trajectories would suggest that the chance of this is declining. Any further elevated levels easing into Day 2 (07 Aug).

Risk decreases further through Day 3 (08 Aug), as the main active region currently will rotate further away from Earth on the far-side, with the proton flux expected to remain at background levels. The other sunspot regions on the disc currently are unlikely to produce significant proton enhancements.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	40	20	10	5
Very Active	**≥ S3 ***	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest 24hr GOES16 Proton Flux



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High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 10 MeV) observed by GOES16 is currently at background levels, but likely became enhanced at lower orbits with the recent CME arrival. As any residual CME influence wanes Day 1 (06 Aug), flux is likely to see a rise. The extent and persistence of any such rise is low confidence however, with the potential for further CME arrivals Days 2-3 (07-08 Aug), with effects continuing through Day 3. Any such arrivals are likely to cause a drop out in observed flux, at least for the period of increased solar wind pressure, before flux potentially rises again on Day 4 (09 Aug) as the CME influence recedes.

Overall, the associated 24 hour fluence is likely to stay below the Active level, however there is a slight chance of this rising above, mainly early Day 2 (07 Aug) before anticipated CME arrivals. REFM is likely to be unreliable in this period, due to the potential CME arrivals.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^{8}$	No	10	20	10	20
Very Active	≥ 2 MeV ≥ $1x10^{9}$	No	1	1	1	1

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